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Trial Burn Testing of the EPA-ORD Mobile Incineration System

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16. ABSTRACT

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ENVIRONMENTAL RESEARCH BRIEF

Trial Burn Testing of the EPA-ORD Mobile Incineration System

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This summary describes the initial trial burn testing of the mobile incineration system that was developed through the EPA Office of Research and Development for destroying organic hazardous materials at spills and abandoned landfill sites. The trial burn test program consisted of a series of five tests designed to evaluate the system's ability to destroy selected hazardous organic materials while controlling the emissions of HCl, particulate matter, and organics according to the requirements of the Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), and the State of New Jersey. The results of the trial burn provided the information needed to obtain operating permits for the incineration system at many of the hazardous material sites that plague the nation.

Introduction

Continuing discoveries of abandoned hazardous material waste sites have placed increased pressure on the U.S. Environmental Protection Agency (EPA) to find long-term solutions to this problem. Technology such as high-temperature thermal incineration currently exists to destroy many of the wastes, but problems associated with siting and the public uncertainty about incineration have minimized its use. A promising means of using incineration technology is through a mobile system that is brought to a waste site, used to destroy the hazardous material, and then removed from the site. The unit's mobility enables the liquid or solid hazardous materials to be destroyed onsite. Thus local problems are solved by avoiding creation of a permanent site to which other wastes will be brought and by eliminating transportation of wastes through the community, which is frequently a major objection of the local citizens.

Since incineration of hazardous materials is controlled by State and Federal regulations, a trial burn plan was developed to demonstrate the Mobile Incineration System's compliance with the regulations and to provide a basis for obtaining State and Federal permits. This plan was approved by the permitting agencies, and the trial burn tests were conducted in three test phases from September 1982 through January 1983 at the Municipal Environmental Research Laboratory's Oil and Hazardous Materials Spills (OHMS) Branch in Edison, New Jersey. The tests evaluated the ability of the Mobile Incineration System to destroy carbon tetrachloride (CCl_4), di-, tri-, and tetrachlorobenzenes (TCBs), and polychlorinated biphenyls (PCBs) while controlling the emissions of HCl and particulate matter. The trial burn consisted of 25 test runs, during which the incinerator's operating conditions were monitored and an extensive sampling and analytical program was conducted to measure gaseous, liquid, and solid discharges. All test runs were conducted with the appropriate State and Federal observers onsite to ensure that the incineration system was operated safely and according to the conditions of the trial burn permits.

Procedures

The trial burn plan was developed according to the requirements of the Federal Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), and the New Jersey Department of Environmental Protection (NJDEP) Administrative Code (NJAC). In addition to satisfying these requirements, the investigators developed a series of step-by-step test procedures to provide maximum opportunity for safely detecting potential problems in the system's performance. This approach was designed to minimize the risk of any undesirable exposures of emissions.

The trial burn plan consisted of five tests—one that used clean diesel fuel oil and four that used different synthetic waste materials. A baseline test for particulate and organic

emissions was conducted while burning clean diesel fuel in both the primary (rotary kiln) and secondary combustion chambers. The data from the diesel fuel test provided background emission data for comparison with other tests.

During the second test, the particulate removal efficiency of the air pollution control (APC) equipment was measured by feeding a mixture of finely ground iron oxide (Fe_2O_3) and clean diesel fuel into the rotary kiln. The particulate matter content of the stack gases was measured to verify the effectiveness of the APC equipment in removing particulate matter.

The third test was designed to demonstrate the destruction and removal efficiency (DRE) of organic compounds regulated by RCRA. The compounds chosen—carbon tetrachloride and o-dichlorobenzene—were blended with diesel fuel and burned in the rotary kiln. These compounds were chosen because they are considered to be very refractory (difficult to incinerate) according to EPA's ranking of incinerability of RCRA-regulated compounds. The combustion of these compounds also generated hydrochloric acid (HCl), which afforded the opportunity to evaluate the APC equipment for removing HCl from the combustion gases.

The fourth test category consisted of two tests during which different mixtures of PCB (as Askarel*) in diesel fuel were burned. The particular Askarel used is a mixture of Aroclor 1260 (a typical PCB), trichlorobenzenes, and tetrachlorobenzenes, and it was mixed with diesel fuel to generate two different concentrations of synthetic wastes that were fed into the rotary kiln. The concentration of Askarel was 11% by weight in the diesel fuel during one test and 39% in the other.

According to EPA requirements, all organic DRE tests were run in triplicate. Additional particulate removal tests based on NJDEP requirements were also run in triplicate for each of the test feed conditions. Table 1 summarizes the trial burn tests and the feed mixtures used.

Results

The test results from the trial burn can be readily understood by evaluating five principal performance criteria: (1) particulate removal efficiency, (2) HCl removal efficiency, (3) organic DRE, (4) wastewater quality, and (5) ambient air quality. The first three criteria define the major emissions from the stack of the mobile incinerator. These criteria, in addition to wastewater quality, were closely monitored to ensure compliance with State and Federal regulations. The fifth criterion, ambient air quality, is important from a socio-political point of view and is of concern to the citizens in the local community. Each of these performance criteria will be presented separately to provide an organized view of the test results.

Particulate Removal Efficiency

The removal of particulate matter from the combustion flue gas is accomplished in the APC equipment. Particulate matter is generated from the solids, ash, and heavy metals present in liquid wastes incinerated in the rotary kiln. The synthetic organic wastes incinerated during the trial burn were clean liquids free from heavy metals and significant quantities of ash. Thus a test mixture of iron oxide powder and diesel fuel was prepared for determining the particulate removal efficiency of the APC equipment. Iron oxide was chosen because of its availability in the specific particle size range desired for the test (0.4 to 0.9 μm). The concentration of iron oxide in test mixtures ranged from 0.8 to 1.6 wt %. The results of the three test runs appear in Table 2. The particulate removal efficiency exceeded 90% for all test runs. The results also confirm that the APC section, where the primary sub-micron particulate removal device is the Cleanable High Efficiency Air Filter (CHEAF), was able to control the particulate emission rate to within the level set by the regulations (180 mg/dscm according to RCRA). In fact, in Table 2, the particulate emission rate corrected to 7% O_2 in the stack was well below the allowable emission rate.

Particulate emission rates were measured for the other test mixtures even though the mixtures were composed of clean components. The emission rates for the other test runs ranged from 6.3 to 80.2 mg/dscm (corrected to 7% O_2), which was also well below the allowable emission rate.

HCl Removal Efficiency

The release of acid gases (primarily HCl) from the combustion of chlorinated organics is regulated by RCRA. Test 3 of the trial burn used a test mixture rich in organochlorine compounds to quantify the capacity of the APC equipment to remove high levels of HCl from the combustion gases. The HCl removal efficiency and corresponding stack emissions were also measured during Tests 4 and 5 when PCBs were fed to the incinerator, since the feedstocks also had the potential to produce significant quantities of HCl. The results of these tests appear in Table 3 and indicate that the regulatory criteria were met during all trial burn test runs. RCRA restricts HCl emissions to 4 lb/hr or 99% removal of that generated, whichever is greater.

Organic Destruction Efficiency

The efficient destruction of hazardous organic compounds is the primary function of the Mobile Incineration System. Thus the measurement and demonstration of the DRE was the major reason for conducting the trial burn. The compounds selected were carbon tetrachloride, di-, tri-, and tetra-chlorobenzenes, and PCBs.

The DRE results for these compounds (Tests 3, 4, and 5) are illustrated in Table 4. The RCRA-required DRE for hazardous organic compounds such as CCl_4 and TCBs is 99.99%. This RCRA requirement was exceeded during all nine test runs by approximately 10 to 100 times. The results shown in Table 4 do not indicate limits of the incinerator's ability to destroy hazardous organics; rather, in all cases they reflect the limits of our ability to sample and analyze ultra-trace quantities of organics in the stack gas. Most of the stack samples (72 of 93) did not contain enough material to identify and quantitate the test organics, so the quantities used to calculate DREs were level-of-detection values and not necessarily actual emission values. Note that achieving a DRE in excess of 99.99% becomes excessively costly and may serve no useful purpose in terms of the general public health and welfare. The analyst's ability to quantitate

*Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA or IT Corp.

Table 1. *Trial Burn Test Summary*

Test No.	Phase No.	Feed Material[a]	Number of Runs	Test Purpose
1	1	Diesel fuel	2 DRE[b] 2 Particulate	Baseline performance
2	2	1.2% Fe_2O_3 [c] 98.8% Diesel fuel	3 Particulate	Particulate removal efficiency of APC
3	2	21.4% CCl_4 [d] 28.9% $C_6H_4Cl_2$ [e] 49.7% Diesel fuel	3 DRE 3 Particulate	Destruction of RCRA organic; HCl removal efficiency of APC
4	3	11.4% Askarel[f] 88.6% Diesel fuel	3 DRE 3 Particulate	Destruction of PCB (TSCA); HCl removal efficiency of APC
5	3	39.3% Askarel[f] 60.7% Diesel fuel	3 DRE 3 Particulate	Destruction of PCB; HCl removal efficiency of APC

[a] All compositions are reported on a wt/wt basis.
[b] Destruction and removal efficiency of principal organics.
[c] Iron oxide.
[d] Carbon tetrachloride or tetrachloromethane.
[e] Ortho-dichlorobenzene or 1,2-dichlorobenzene.
[f] 58.9% Aroclor 1260, 35.0% trichlorobenzenes, 6.1% tetrachlorobenzenes.

Table 2. *Summary of Particulate Removal Results for Test 2*

Item	Test Number and Date 2E 10/21/82	2G 10/22/82	2I 10/23/82
Waste feed:			
Fe_2O_3 (lb/hr)	1.66	2.60	3.31
Stack:			
Flowrate (dscfm)	4016	3940	4113
Fe_2O_3 (lb/hr)	0.145	0.100	0.157
Fe_2O_3 removal efficiency (%)	91.2	96.2	95.3
Total particulate matter[a] (mg/m^3)	23.7	25.8	16.7

[a] Corrected to 50% excess air (7% O_2) in accordance with RCRA.

Table 3. *Summary of HCl Removal Results*

Item	Test 3 Average	Test 4 Average	Test 5 Average
Waste feed:			
HCl in feed[a] (lb/hr)	88.97	15.27	52.83
Stack:			
HCl emission (lb/hr)	0.040	0.002	0.003
Removal efficiency (%)	99.96	99.98	99.99
HCl concentration (ppm)	1.6	0.13	0.18

[a] Based on chlorine content of test feed (refer to Table 1 for waste feed composition).

Table 4. *Summary of Organic Destruction Results*

Item	Test 3 Average	Test 4 Average	Test 5 Average
Waste feed (lb/hr):			
CCl_4 [a]	70.1	---	---
DiCIB[b]	94.9	---	---
TriCIB[c]	---	8.43	33.2
TetraCIB[d]	---	1.40	6.4
PCB[e]	---	14.6	50.0
Stack gas (lb/hr):			
CCl_4 [a]	$<3.2\times10^{-5}$	---	---
DiCIB[b]	2.4×10^{-5}	---	---
TriCIB[c]	---	$<1.4\times10^{-5}$	$<2.1\times10^{-5}$
TetraCIB[d]	---	$<8.8\times10^{-6}$	$<8.8\times10^{-6}$
PCB[e]	---	$<2.8\times10^{-5}$	$<4.3\times10^{-5}$
DRE (%):			
CCl_4 [a]	>99.99995	---	---
DiCIB[b]	99.99998	---	---
TriCIB[c]	---	>99.9998	>99.99993
TetraCIB[d]	---	>99.9994	>99.9998
PCB[e]	---	>99.9998	>99.99991

[a] Carbon tetrachloride.
[b] O-dichlorobenzene.
[c] Trichlorobenzenes.
[d] Tetrachlorobenzenes.
[e] Polychlorinated biphenyls (Aroclor 1260).

increasingly lower levels of chemicals should not result in a demand that the treatment equipment be redesigned to demonstrate a level of performance that meets or exceeds the most recently achievable limit of detection.

Another measure of the performance of the incineration system is the combustion efficiency or the ratio of the

concentrations of carbon monoxide (CO) to carbon dioxide (CO_2) according to the formula:

$$\text{Combustion efficiency} = 100\% \times [CO_2]/([CO_2]+[CO])$$

The required performance level under this criterion, according to TSCA, is 99.9%. The concentration of CO during the trial burn tests was so low—less than 1 ppm—that it was lower than the detection level of either of the two gas monitors (nondispersive infrared and gas chromatography) installed to measure it. The low CO concentration raised the combustion efficiency above 99.999%, or 100 times better than the required performance.

Wastewater Quality

The wastewater from the APC section of the incineration system was monitored for total organic carbon, pH, temperature, total dissolved and suspended solids, petroleum hydrocarbons, volatile organics, and test organic compounds. The results of hourly, daily, and weekly sampling and analyses of the wastewater are summarized in Table 5. The average concentration of the test organics in the wastewater was lower than 20 $\mu g/L$ (ppb) during the entire trial burn. The main contaminants in the wastewater were dissolved salts from the neutralization of acid gases (HCl and SO_2) by the scrubbing solution (sodium bicarbonate).

Ambient Air Quality

The personnel and site monitoring programs consisted of the collection of air samples in the immediate vicinity of the Mobile Incineration System and around the test site to determine the impact of the stack gas and fugitive emissions on air quality. Data from the personnel monitoring stations indicated low levels of tri- and tetra-chlorobenzenes (<0.1 mg/m^3) near the waste feed tank and rotary kiln. The concentration of chlorobenzenes detected is much lower than the level considered to be an industrial hygiene hazard. No evidence of PCBs was found in any personnel monitoring samples.

In the site monitoring program, ambient air samples were collected 0.3 to 1.0 km downwind from the incinerator stack. No measurable quantitites of chlorobenzenes or PCBs were found. The detection level was 0.1 $\mu g/m^3$ for both tri- and tetra-chlorobenzene and 1.0 $\mu g/m^3$ for PCBs (as Aroclor 1260). These data demonstrate that the mobile incineration system does not adversely affect the quality of air in the local community.

Conclusions

The trial burn was conducted to verify that the Mobile Incineration System could achieve compliance with Federal and State (New Jersey) regulations governing the incineration of hazardous and toxic substances. During the trial burn tests the incineration system achieved over 99.99% destruction of synthetic wastes at feed rates of up to 70 lb/hr of carbon tetrachloride, 95 lb/hr of chlorinated benzene, and 50 lb/hr of PCB (as Aroclor 1260). The system's control and monitoring instrumentation was demonstrated to be capable of maintaining the required levels of performance.

The results of the trial burn confirmed that the air pollution control section of the Mobile Incineration System removed HCl (over 99%) and particulate matter (to less than 180 mg/m^3 corrected) in accordance with the requirement of State and Federal regulations. An ambient air monitoring program, conducted during the trial burn, verified pre-trial burn EPA air modeling which indicated that the quality of the air in the local community would not be adversely affected by the incinerator emissions.

The results of the trial burn tests demonstrate that the Mobile Incineration System is capable of meeting and exceeding all applicable Federal regulations. The large quantity of data collected and analyzed (over 10,000 pages of log sheets, chromatograms, calibrations, and results tables) clearly support the conclusion that the EPA Mobile Incineration System is a complete and efficient hazardous material destruction process.

Table 5. *Summary of Wastewater Analyses*

Parameter	Test Week				
	9/12/82	10/18/82	10/25/82	1/4/83	1/10/83
Daily flow (gal/day), average	4,298	4,962	5,141	5,613	9,211
Total organic carbon (mg/L), average	155	16	7	13	20
Temperature range (°C)	52-82	36-75	58-72	32-67	26-57
pH range	7.5-10	6.5-11	7-9.5	8.5-9	7.5-8.5
Petroleum hydrocarbons (mg/L), average	<1.0	<1.0	<1.0	2.6	1.5
Total dissolved solids (mg/L), average	17,600	14,000	20,500	3,360	12,900
Total suspended solids (mg/L), average	338	65	68	55	36
Volatile organics (µg/L), average	86-99	133	<10	*	10

*Not measured.

This overview of the trial burn results represents only a small fraction of the total data collected and generated. Voluminous test data were collected in order to identify the performance capability of the Mobile Incineration System at design operating conditions. Evaluation of the data indicates that under these conditions, the system meets or exceeds all performance criteria established by State and Federal regulations. From this viewpoint, the trial burn was a success and the Mobile Incineration System should be considered an optimum technical solution for many of the organic hazardous waste disposal problems now facing the Nation.

Recommendations

The trial burn program described in this summary was limited to the testing of organic liquids. To use the Mobile Incineration System over the entire range of hazardous wastes, the unit must be able to detoxify solid hazardous materials such as PCB- and dioxin-contaminated soils. An additional trial burn program will be required to provide the data necessary to obtain State and Federal permits for handling solids. A test program should be designed to test worst-case waste feed materials so that the need for additional testing in the future will be minimized or eliminated.

The operating conditions used during the trial burn were those for which the Mobile Incineration System was designed and those required in the TSCA for incineration of PCBs. The high combustion efficiencies and DREs achieved indicate that these conditions are more than adequate to meet the RCRA requirements both for organic DREs and for particulate matter and HCl emission limitations. Consideration should be given to changing the operating conditions to allow a higher processing rate of RCRA-regulated hazardous materials as long as regulated performance criteria are met. A higher processing rate for hazardous material and a lower diesel fuel consumption rate would substantially reduce the cost of using the Mobile Incineration System to destroy hazardous wastes.

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